

Amendments to the Specification

Please amend the paragraph on page 1 at line 5 as follows:

CROSS-REFERENCE TO RELATED APPLICATIONS

This application ~~takes priority under 35 U.S.C. ' 119(e) from~~, which claims the benefit of U.S. ~~provisional patent application~~ Provisional Application 60/427,742, filed November 19, 2002, and is a continuation-in-part of pending U.S. ~~application~~ Application serial no. 10/358,404, filed February 3, 2003 which in turn claims the benefit of U.S. Provisional Application 60/367,891, filed March 25, 2002; U.S. Provisional Application 60/388,322, filed June 13, 2002; and U.S. Provisional Application 60/420,694, filed October 22, 2002. Each of these applications is incorporated by reference herein in its entirety ~~to the extent that it is not inconsistent with the disclosure herein.~~

Please amend the paragraph bridging pages 13 and 14 as follows:

The catalysts useful for the present invention which have been found to exhibit the listed properties are mixed metal oxides comprising a low oxidation activity metal oxide selected from the group of titania, zirconia, silica, alumina or mixtures thereof in combination with one, two, three, four or more metal oxides having a higher oxidation activity compared to the low oxidation activity metal oxide. Both alpha alumina and gamma alumina are useful as low oxidation activity metal oxides. The higher oxidation activity metal oxides can be transition metal oxides, lanthanide metal oxides or both selected from oxides of V, Cr, Mn, Fe, Co, Ni, Cu, Nb, Mo, Tc, Ru, Rh, Pd, Hf, Ta, W, Re, Os, Ir, Pt, Au, La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, or mixtures thereof. Preferred high oxidation activity transition metal oxides are those that are oxides of V, Cr, Mn, Fe, Co, Ni, Cu, Nb, Mo, W, and mixtures thereof. A preferred high oxidation activity lanthanide metal oxide is that of La. More preferred higher oxidation activity metal oxides are oxides of V, Cr, Mn, Fe, Co, Ni, Cu, Nb, Mo, or mixtures thereof. Yet more preferred higher oxidation activity metal oxides are oxides of Nb, Mo, Cr, Mn, Fe, Co or Cu. Preferred mixed oxide catalysts of this invention comprise two, three or four high oxidation activity metal oxides.

Please insert the following paragraph on page 14, after the paragraph which ends at line 21:

Selected catalysts useful for the invention include: those containing from 0.1% to about 10% by weight of an oxide of Mo, an oxide of Nb or both and from about 1% to about 10% by weight of an oxide of Fe, Cu or Co; those comprising about 1 to about 10% by weight copper oxide, about 1 to about 10% by weight niobium oxide, and about 0.1 to about 1% by weight molybdenum oxide with the remainder being titania or a mixture of titania and silica; those comprising about 1 to about 10% by weight iron oxide, about 1 to about 10% by weight niobium oxide, and about 0.1 to about 1% by weight molybdenum oxide with the remainder being titania or a mixture of titania and silica; and those comprising about 1 to about 10% by weight cobalt oxide, about 1 to about 10% by weight niobium oxide, and about 0.1 to about 1% by weight molybdenum oxide with the remainder being titania or a mixture of titania and silica.

Please amend the paragraph at page 16, line 3 as follows:

Exemplary catalysts useful for the invention include those which comprise about 0.4% to about 6% by weight of molybdenum oxide in combination with titania, zirconia, silica, alumina or a mixture thereof. Exemplary catalysts useful for the invention include those which comprise about 0.4% to about 6% by weight of molybdenum oxide and about 0.4% to about 6% by weight of niobium oxide in combination with titania, zirconia, silica, alumina or a mixture thereof. Exemplary catalysts useful for the invention also include those which comprise about 4% to 6% by weight of iron oxide; cobalt oxide or copper oxide or a mixture thereof, about 4% to about 6% by weight of niobium oxide and about 0.4% to about 6% by weight of molybdenum oxide in combination with titania, zirconia, silica, alumina or a mixture thereof. Exemplary catalysts useful for the invention include those which comprise about 4% to 6% by weight of iron oxide, cobalt oxide, or copper oxide or a mixture thereof, about 4% to about 6% by weight of niobium oxide and about 0.5% to about 1% by weight of molybdenum oxide in combination with titania. Further exemplary catalysts useful for the invention include those which comprise about 5% by weight

~~Iron~~ iron oxide; cobalt oxide or copper oxide, about 5% by weight of niobium oxide and about 0.5% to about 1% by weight of molybdenum oxide in combination with titania, zirconia, silica, alumina or a mixture thereof. Yet further exemplary catalysts useful for the invention include those which comprise about 5% by weight ~~Iron~~ iron oxide; cobalt oxide or copper oxide, about 5% by weight of niobium oxide and about 0.5% to about 1% by weight of molybdenum oxide in combination with titania.

Please insert the following paragraph on page 16, after the paragraph which ends at line 30:

Silica, silica gel or other binders can also be used in the preparation of catalysts of this invention and the exact nature of the binder is unimportant; however, in the preferred formulation, aluminum oxide is avoided to minimize any sulfation reactions that may occur by reaction of the aluminum oxide with SO₂. The amount of binder can vary from 1 wt% to 25 wt% with the preferred amount being 10% of the original weight of the powder mixture (e.g. 10 gm of binder for each 100 gm of mixed powders). Mixed metal oxide catalysts of this invention can comprise up to about 105 by weight of a binder. The preferred binder is silica.

Please insert the following paragraph on page 17 after the paragraph ending on line 9:

Catalysts useful in this invention include those prepared by calcining a mixed metal oxide powder at a temperature of about 300°C to 550°C and those prepared by calcining a mixed metal oxide powder at a temperature of about 400°C to 450°C.

Please amend the paragraph on page 17 starting at line 26 as follows:

The surface area of a given catalyst can be measured using methods that are well-known in the art and surface area of a given catalyst can be adjusted or selected using methods that are well-known in the art. Catalysts of this invention include those having a surface area ranging from about 50 to about 150 m²/g.

Please amend the paragraph that contains Table 3 on page 21 between lines 19-30 as follows:

Table 3: Typical composition of Syngas
from a gasifier

N2 N ₂ (g)	1.9%
Ar(g)	0.6%
CO2 CO ₂ (g)	15.8%
CO(g)	45.3%
H ₂ H ₂ (g)	34.4%
Hg(g), ppbv	10
CH4 CH ₄ (g)	1.9%
H2S H ₂ S(g)	0.9%

Please amend the paragraph bridging pages 26 and 27 as follows:

H₂S Oxidation and Hg Removal Combined with Biological Sulfur Removal

Fig. 5 schematically illustrates an exemplary process configuration combining the direct oxidation and Hg removal reaction of this invention with a biological process for conversion of H₂S and/or SO₂ to sulfur. The process is illustrated for treatment of natural gas or syngas, but can be applied to other gas streams containing sulfur-containing components. In this configuration, sour gas enters (through inlet 803) the oxidation and Hg removal process (601) and sulfur and mercury generated therein is removed by condensation. Gas exiting the reactor (807) which may contain unreacted H₂S, is introduced into the biological sulfur removal process (809) (illustrated by the Shell-Paques process). As illustrated the oxidation reaction is operated to maximize partial oxidation to sulfur for removal. In the biological process, H₂S is converted in a first step to sulfide, e.g. in a caustic reactor, and the sulfide is converted by selected microorganisms (e.g., sulfur bacteria) to sulfur. Cleaned or sweetened gas exits the biological process (811) or may be passed to another processing system.

Please amend the paragraph bridging pages 27 and 28 as follows:

H₂S Oxidation and Hg Removal Combined With a Split Flow Claus Process

The inventive catalytic oxidation process can be used to replace the furnace in a split flow Claus plant for processing low concentrations of H₂S. The split flow Claus process is typically used for gases containing low concentrations of H₂S and is especially attractive for H₂S concentrations below 12% (Alcoa, 1997). Fig. 6 schematically illustrates a sulfur removal/recovery configuration in which a direct

oxidation and Hg removal reactor of this invention (e.g., the reactor of Fig. 1) is positioned upstream of a liquid Claus unit. Sour gas from a source containing a low concentration of H₂S (e.g., 40% or less) is split (904 and 903). A portion of the feed gas stream (904) is directed into the Claus unit (909) and a portion (903) is introduced into the oxidation and Hg removal process (601). By controlling the amount of air added to the catalytic reactor (601) and operating at moderate temperatures (ca < 200°C), H₂S in the split stream (903) can be converted into SO₂ and elemental sulfur. Gas exiting the oxidation process (907) containing SO₂ is passed to the Claus unit and sulfur generated in the oxidation process is condensed. A third or more of the feed gas flow can be sent through the direct oxidation process. Diversion of feed gas flow decreases the total sulfur load on the Claus converters. After processing through the Claus process, elemental sulfur is recovered and tail gas (911) exits the system. Dependent upon the residual levels of H₂S in the tail gas, it may be recycled through the oxidation process or passed into a second catalytic reactor for additional sulfur generation.

Please amend the paragraph on page 28 starting at line 21 as follows:

Fig. 7 illustrates sour gas introduced (1003) into the oxidation and Hg removal process (601). Any unconverted H₂S and SO₂ generated in the oxidation process (1007) are passed into the SCOT process (1009) and residual H₂S and H₂S generated during hydrogenation/hydrolysis is recycled back (1005) to the oxidation process. Sweetened gas exits (1011) or is passed to another process system.

Please amend the paragraph that is Table 4 on page 31 (top of the page) as follows:

Table 4

Gases	%
N2 N ₂ (g)	1.753
Ar(g)	0
CO2 CO ₂ (g)	14.576
CO(g)	41.79
H ₂ H ₂ (g)	31.734
Hg(g)	0
H2O H ₂ O(g)	9.225
S(g)	0.923
S2 S ₂ (g)	0
S3 S ₃ (g)	0

S4 <u>S</u> ₄ (g)	0
S5 <u>S</u> ₅ (g)	0
S6 <u>S</u> ₆ (g)	0
S7 <u>S</u> ₇ (g)	0
S8 <u>S</u> ₈ (g)	0

Please amend the paragraph on page 32 which starts at line 7 as follows:

An example of how the maximum allowable H₂S concentration is calculated is discussed below. Sulfur vapor-liquid-equilibrium (VLE) calculations can be readily performed for different temperatures and concentrations of sulfur vapor. At T = 250°C for 2000 ppm of elemental sulfur vapor condensation starts at a pressure of 72 bar (1044 psi). For the TDA#2 (5%Fe₂O₃/0.5%MoO₃/5%Nb₂O₅/TiO₂) catalyst the best conditions observed were O₂/H₂S = 1.5 and T = 250°C. Under these conditions the selectivity for sulfur was 30% and the selectivity for SO₂ was 70%. Assuming that the pressure affects the sulfur dew point more than the kinetics of the catalytic reaction, then the maximum concentration of H₂S that could be present in the reactor feed would be 6666 ppm for these values of S and SO₂ catalyst selectivity. These pressures (72 bar) and concentrations (6000+ ppm) are somewhat approximate because the calculations do not include corrections for non-ideal gas behavior; however, the calculations do indicate that natural gas streams containing a fairly wide range of H₂S concentrations at pressures of interest (i.e., pressure up to 1000 psi) can be processed in using catalysts of this invention.

Please amend the paragraph on page 32 which starts at line 21 as follows:

Those of ordinary skill in the art will appreciate that methods and known in the art and can be applied or readily adapted to the practice of this invention without resort to undue experimentation. For example, methods for synthesis of mixed metal oxides other than those specifically exemplified are known in the art and can be applied to the preparation of catalysts. All art-known equivalents of materials, methods specifically exemplified herein are intended to be encompassed by this invention. All references cited herein are incorporated by reference ~~herein to the extent that they are not inconsistent with the disclosure herein.~~

Please amend the Abstract on page 42 as follows:

ABSTRACT OF THE INVENTION

~~The invention relates to a~~ A process for removing hydrogen sulfide, other sulfur-containing compounds and/or sulfur and mercury from a gas stream contaminated with mercury, hydrogen sulfide or both. The method comprises the step of selective oxidation of hydrogen sulfide (H_2S) in a gas stream containing one or more oxidizable components other than H_2S to generate elemental sulfur (S) or a mixture of sulfur and sulfur dioxide (SO_2). The sulfur generated in the gas stream reacts with mercury in the gas stream to generate mercuric sulfide and sulfur and mercuric sulfide are removed from the gas stream by co-condensation.